***EE/CprE/SE 4920 Status Report 1***

***01/21/2025 – 01/30/2025***

***number: 36***

***Project title:*** ***Ultrasonic Object Detector***

***Client &/Advisor: Professor Jiming Song***

***Team Members/Role:***
***Nathaniel Clarke - Project Software Designer***
***Brock Dykhuis - Circuit Analysis***
***Nicholas Jacobs - Electronics***
***Jonathon Madden - UI Designer & Software Tester***

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**Weekly Summary**

Currently, we have an initial working circuit without steering implemented. We have the initial pulse control code developed in Arduino, but it requires some troubleshooting; the values being received are unexpected. We also experienced issues with the display accessing values received; additional testing will be needed.

**Past week accomplishments**

**Brock Dykhuis** - Theoretical design with Python code, this is used to communicate between the MQTT server and the MCU

- had to do research into Python as I am not all that familiar with it

**Nicholas Jacobs**- Focused mainly on research and began identifying additional components needed for the transmitters to align with the phased array concept

**Jonathon Madden -** Tried to learn more about why we weren't getting accurate readings from the circuit when we tested it the first time. Went over the code we use to try and find where it failed.

**Nathaniel Clarke -**

- Investigated possible causes for unexpected readings:
    - Potential causes include the sensitivity of readings (a past implementation used 200 for the analog value; this may need to be increased based on further testing)

- Additionally, the length of the pulse may be affecting the accuracy, a shorter pulse may prevent unwanted interference

```
while (analogRead(A0) < 200 && !cancelRead)
```

- Researched phase delay formulas and read and took notes on "OPTIMIZATION OF ULTRASONIC PHASED ARRAYS"
  - The function for time delays for transmitting sources was given as follows: $\Delta T = \frac{dsin(\theta_s)}{c}$ with d being the distance between sources (transmitters), $\theta_s$ being the steering angle, and c being the wave speed (343 m/s)
  - The paper also mentioned the transmitter's critical spacing, which relies on the maximum desired steering angle. The equation for critical spacing distance was given as follows: $d_{cr} = \frac{1}{1+sin(\theta_s)}$. Note that $\theta_s$ is really Max($\theta_s$).
  - An additional requirement to note is that to scan rightward, the first transmitter to pulse should be the leftmost transmitter, and to scan leftward, the rightmost transmitter should be pulsed first.

- Read and took notes on "Beam focusing behavior of linear phased arrays"
  - Presented same time delay formula from "OPTIMIZATION OF ULTRASONIC PHASED ARRAYS"
  - The text presented fundamental parameters to track: Frequency, element width, center-to-center spacing of elements, total aperture dimension, and elevation dimension.
  - The text presented the concept of a transition range of an array. Before reaching a distance of this range, focusing is said to be more effective than steering. The formula was given as $Z_{TR} = \frac{D^2}{4\lambda}$ where D is the overall dimension of the array (in our case, it is 1), and lambda is the wavelength of pulses.
  - The multiple forms of the time delay account for beam focusing, with one form using the steering delay formula. The first formula was as follows: where $\overline{N} = \frac{N-1}{2}$, N is the number of sources, and F is the focal point.

$$t_n = \frac{F}{c}\left\{\left[1 + \left(\frac{\overline{N}d}{F}\right)^2 + \frac{2\overline{N}d}{F}\sin\theta_s\right]^{1/2} - \left[1 + \left(\frac{(n-\overline{N})d}{F}\right)^2 - \frac{2(n-\overline{N})d}{F}\sin\theta_s\right]^{1/2}\right\}$$

  - The second formula is as follows: where $\Delta t$ follows the formula for steering delay. N and F are the same as above, and n is the particular transmitter.

$$= n\tau_0 + \frac{c\Delta\tau_0^2}{2F\tan^2\theta_s}(nN - n^2 - n).$$

- Began coding Phased array code for the MCU (Steering implementation).
    - Currently using placeholder data until transmitter spacing and pins are solidified.
        - The current distance is given as $d_{cr}$ assuming a FOV of 60 degrees in both directions.
    - Currently is using coroutines for concurrency like the 2023 implemented, this may need to be changed to improve efficiency.

**Individual contributions**

| NAME | Individual Contributions | Hours this week | HOURS cumulative |
|---|---|---|---|
| Nathaniel Clarke | Researched phased array formulas and optimization. Reviewed display and MCU to try to diagnose current issues. Began work on phase array code for steering. | 11 | 75 |
| Brock Dykhuis | Research in Python that will be used to complete communication over WIFI | 10 | 71 |
| Jonathon Madden | Looked over the code to try and figure out why it did not work properly | 4 | 54 |
| Nicholas Jacobs | Research on upcoming components for transmitters | 5 | 60 |

**Comments and extended discussion**

ISU WI-FI sucks and is not able to be changed to make things easy for us. We will need to figure out how to work with what we are given.

- Netreg the MCU and get that connected
- Unable to get a static IP on the MCU, so we will need to manually update the Arduino code each time we test our project

Additional testing is required, but a separate clock device may be needed to get phase delay accuracy down to the nanosecond. With the current MCU setup, the only way to delay for a few nanoseconds is with NOPs.

**Plans for the upcoming week**

**Brock Dykhuis** - Complete communication between the MCU and PI, and upload that data to the server. Update UI to be able to read from the server.

**Nicholas Jacobs**- Editing the transmitters to go along with the phased array concept. The focus will be on adjusting signal timing and synchronization to ensure proper phase alignment for improved detection accuracy.

**Jonathon Madden -** Work on testing the transducers to get an accurate reading, and fix the code. Make sure the software is connected properly to the transducers.

**Nathaniel Clarke -** Working on phase delay code and testing on the circuit if possible. The current plan is to use coroutines for concurrency, but this may be changed to improve efficiency. If time allows, additional features will be added to the radar display.

**Summary of weekly advisor meeting**

During this week's meeting we discussed our plans for this semester for this project. We also went over what was accomplished last semester.